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particulate control in energy processes: a status report

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The Particulate Control in Energy Processes Symposium was held in San Francisco on May 12-14, 1976. Topics of discussion included use of low sulfur coals, electrostatic precipitators for low sulfur coal, baghouses and scrubbers as alternatives to ESP's for power plants using low sulfur coal, and high temperature, high pressure energy processes. This article presents the significant findings of the 22 papers delivered, and summarizes the conclusions of the discussions between the speakers and the audience.

The Particulate Control in Energy Processes Symposium was held in San Francisco on May 11-13. It was sponsored by the EPA and EPRI and hosted by the Aerotherm Division of Acurex Corporation. About 300 people heard 22 speakers and two panel discussions on the current status of particulate control technology. A Proceedings of the symposium is available from EPA as Report No. EPA-600/7-76-010, dated September 1976.

The symposium dealt with particulate control for both conventional and advanced energy systems. Since conventional systems will be able to meet future energy demands largely through coal combustion, emphasis was placed on the problems of burning coal in utility boilers. The discussion of advanced energy systems concentrated on fluid bed combustion and gasification combined cycle.

One of the main issues involved in

burning coal is the effect of different types of coal on particulate emissions. In many cases, sulfur dioxide emission standards can be met simply by using low sulfur coal. In other cases, a low level of flue gas desulfurization is necessary along with low sulfur coal to reduce emissions.

The discussion of low sulfur coals brought up two questions: 1) where will these coals be used? and 2) what will be the impact of their use? According to R. Schmidt of EPRI, the reserves of low sulfur coal ($\leq 0.7\%$ S) as of January 1, 1965, were 68,185 million tons. Reserves are deposits ready to be mined and used. Of this total, 5,735 million tons were in the Appalachian region and 61,960 million tons were in the Rockies. By comparison, total resources of low sulfur coal, including undiscovered seams, were estimated to be 626,500 million tons. According to G. Green of Public

Service Company of Colorado, burning low sulfur coals in utility boilers will have an impact on both processing and transportation. There will need to be changes in pulverizer design and increased primary air for pulverizer drying. Boiler thermal efficiencies will also have to be changed. In addition, present rail transportation and unloading facilities at power plants are inadequate and will have to be expanded.

Both W. Talley of EPA and Green noted that switching to low sulfur coal reduces the efficiency of electrostatic precipitators in collecting particulate emissions. Since electrostatic precipitators are the most common particulate control device in power production, low sulfur coals will make particulate emission standards for utility boilers more difficult to meet with standard equipment. As a result, electrostatic precipitators will either have to be replaced by scrubbers or fabric filters, or there will need to be a change in the way electrostatic precipitators are used to improve their efficiency.

One way to improve electrostatic precipitator performance is through flue gas conditioning. In a review of techniques for conditioning flyash, E. Dimukes of Southern Research Institute emphasized conditioning with injection of sulfur trioxide (SO_3). Although any high resistivity ash could be suitably treated with SO_3 , preliminary results show that about 30% of the injected SO_3 is lost out the stack. K. Watson of the Electricity Commission of New South Wales reported that conditioning with SO_3 is now being used in Australia. The Australians have also tried steam, anhydrous ammonia, phosphorous pentoxide, and triethylamine as conditioning agents. Electrostatic precipitator performance was improved significantly by using 20 to 30 ppm of SO_3 .

S. Cragle of Pennsylvania Power & Light Company (PP&L) discussed experience with flue gas conditioning in this country. Several proprietary agents were tested at the Montour Station of PP&L, where a switch from 2.5% sulfur coal to 1.0% sulfur coal increased particulate emissions by a factor of 6 to 9. Use of some of the conditioning agents reduced emissions significantly, although the reduction was only half as great as that originally expected based on tests run with ash from the high sulfur coal. Cooling the flue gas, using a larger precipitator, or collecting the particulate before the air preheater are other options which were discussed to improve electrostatic precipitator efficiency with low sulfur coals.

All of these electrostatic precipitator options must be weighed against the possibility of using an alternate particulate control device—a fabric filter or scrubber. Two utility boiler installations currently used fabric filters for particulate control. According to H. Spagnola of PP&L, particulate control efficiencies were 99.88% for new bags and 99.93% for bags with about 2 years prior service at the Sunbury Station of PP&L. At the Nucla Station of Colorado Ute Electric Association, the particulate control efficiency of fabric filter ranged from 99.92 to 99.98%, as tested by D. Ensor of Meteorology Research, Inc.

In another test by Ensor, the efficiency of a turbulent contacting absorber (TCA) scrubber at the Cherokee Plant of Public Service Company of Colorado was 92%. This is about the same as the results from the Mohave Station reported by D. Jones of Southern California Edison Company. At Mohave, three scrubbers were tested: a TCA; a polygrid packed absorber (PPA); and a horizontal cross flow scrubber. At normal operating conditions, all three scrubbers removed between 90 and 93% of the particulate.

These tests show that both scrubbers and fabric filters can be used for particulate control at power plants. This means that scrubbers and fabric filters should be considered for use with low sulfur coal along with the different electrostatic precipitator options.

The symposium's final session dealt with measuring and cleaning particulates and other pollutants from high temperature and pressure (HTHP) gas streams. S. Calvert of APT, Inc. reviewed the effects of HTHP on all practically important collection mechanisms. Calvert concluded that, in general, high pressure reduces the effectiveness of particle collection mechanisms. For a given pressure, high temperature further lowers the collection efficiency for large particles, but may improve the collection of particles smaller than 0.1–0.5 μm diameter. Calvert also believes that it is unlikely that any new type of collection device will be developed that can remove particles from HTHP gases more effectively than at standard conditions.

In the second paper of the session, D. Blann of Aerotherm Division of Acurex Corporation discussed ways of measuring high temperature and pressure gas streams. His paper offered a state-of-the-art review of various approaches to the formidable task of sampling streams at up to 100 atm. and 1000°C. Several different HTHP sampling rigs were described and compared. This was fol-

lowed by a discussion of problem areas in HTHP sampling. Design considerations for developing sampling apparatus and performing HTHP sampling operations were also talked about, and a brief description of current activities in this area was given.

R. Hoke of Exxon Research and Engineering Company reviewed particulate control, practice, and future needs for fluidized bed combustors. This paper included a brief review of the pressurized fluidized bed combustor process development unit. Particulate emission control requirements for fluidized bed combustors were also discussed. Reviewing work recently performed at Westinghouse Research Laboratories, Hoke concluded that turbine erosion is the limiting factor for particulate cleanup requirements. In his opinion, 0.002 gr/scf is a reasonable upper limit for the outlet of a satisfactory high temperature high pressure cleanup device. Based on this figure, a third-stage cleanup device (following two cyclone separators) would have to have an overall efficiency of 98.7%. There was discussion of the effect of particle size on these devices. The author concluded with a description of four types of granular bed filters now under development.

F. L. Robson of the United Technologies Research Center discussed the cleanup requirements for protecting gas turbines in a combined cycle gasifier plant. He concluded that very low concentrations of sulfur (<0.05 mol %), particulates (<0.0012 gr/scf), and alkali metals (<0.6 ppm as sulfate) must be achieved. Robson then compared two proposed gasifier plant cleanup devices: 1) a low temperature multistage aqueous scrubbing system and 2) a high temperature process containing a primary cyclone, a secondary multiclone cyclone array, and tertiary final filter. This comparison showed that the power cost from a gasifier plant using the high temperature cleanup process is about 10% less than from an identical plant using the low temperature cleanup method (21.5 vs. 19.5 mills/kwh). This savings can be made in spite of the fact that the cleanup system capital costs are about twice as great for the high temperature process, primarily because of the greater overall thermal efficiency of the high temperature cleanup method.

General Conclusions

An extensive discussion period after each presentation, along with a panel discussion, led to a consensus on several points by the speakers and the audience.

It was generally agreed that the use of low sulfur Western coals will continue to increase for the foreseeable future. Further, no final solution to the particulate control problems attendant to the use of low sulfur coal can now be specified. For all of the cleanup methods considered—improved ESP's, chemical conditioning of flue gases, baghouse and scrubbers—further research and development is both warranted and likely to occur.

With respect to chemical conditioning, it now appears that although additives can, under some conditions, produce marked improvement in ESP performance, considerable work remains to be done. Many of the available additives are proprietary and of unknown composition, and the environmental and corrosion effects of most additives remain to be evaluated.

There appears to be a definite trend toward consideration of baghouses for cleanup of coal-burning power plants. This is due primarily to the very low levels of particulate emitted by a baghouse-equipped plant, levels lower than any foreseeable clean air regulations. It was reported, for example, that effluent from the stacks of the Nucla power plant of the Colorado Ute Electric Association

had a visibility of 20 km, at times better than the ambient air.

It was generally agreed that improvement in ESP performance will be continued, but that substantial gains will be hard won. The current trend toward increasing ESP size to handle low sulfur coal ash has led to severe reliability problems. For example, ESP's with 2000 rapper mechanisms are now not uncommon, and failure of any of the rappers will degrade overall ESP performance. Considerably more automation must be applied to ESP's both to monitor and dynamically control their performance.

High temperature, high pressure energy processes are in a developmental stage, and one of the key steps in any of these processes—HTHP cleanup of particles and alkali metals—has not yet been demonstrated. It was agreed that limited data on the performance of cleanup devices at HTHP now exist, for several reasons. First, the cleanup devices themselves are relatively new. Second, the number of HTHP test facilities is severely limited. And finally, satisfactory HTHP sampling equipment is only now becoming available. It was felt that considerable progress will be

made in the next few years to demonstrate the effectiveness of HTHP cleanup devices, and to determine the cleanup levels required in order to protect gas turbines. Particularly needed is reliable data relating particle size distribution and mass loading to turbine erosion.

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